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Indian Standard

METHODS OF MEASUREMENT FOR RADIO RECEIVERS FOR VARIOUS CLASSES OF EMISSION

PART 2 RADIO FREQUENCY MEASUREMENTS ON RECEIVERS FOR AMPLITUDE-MODULATED SOUND BROADCAST EMISSIONS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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PART 2 RADIO FREQUENCY MEASUREMENTS ON RECEIVERS FOR AMPLITUDE-MODULATED SOUND BROADCAST EMISSIONS

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(*Continued on page* 44)

CONTENTS

SECTION 4 INTERFERENCE DUE TO INTERNAL SOURCES

SECTION 5 DISTORTION

SECTION 6 MISCELLANEOUS

Indian Standard

METHODS OF MEASUREMENT FOR RADIO RECEIVERS FOR VARIOUS CLASSES OF EMISSION

PART 2 RADIO FREQUENCY MEASUREMENTS ON RECEIVERS FOR AMPLITUDE-MODULATED SOUND BROADCAST EMISSIONS

0. FOREWORD

0.1 This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards on 26 August 1987, after the draft finalized by the Radio Communications Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 The object of this standard (Part 2) is to lay down the procedures for measurements on radio receivers designed for reception of amplitude-modulates sound broadcast transmissions.

0.3 The methods of measurement on AM and EM radio receivers were earlier covered by IS : 614-1964* and IS : 2731-1964† based on IEC Pub 69 'Recommended methods of measurement on receivers for amplitude-modulation broadcast transmissions' and IEC Pub 91 'Recommended methods of measurement on receivers for frequency-modulation broadcast transmissions' respectively. At international level, it has now been decided to bring out a series of publications covering methods of tests for sound broadcast receivers in IEC Pub 315 superseding IEC Pub 69 and IEC Pub 91. Consequently at national level also, it is proposed to follow the IEC trends and develop a series of standards based on the latest IEC Pub. As such this series of standards is being brought out and this shall supercede IS : 614-1964* and IS : 2731-1964†.

0.4 This standard is a part of a series of standards on methods of tests on radio receivers. Other parts likely to be covered in this series are:

Part 1 General considerations and methods of measurements

*Methods of measurements on receivers for amplitude modulation broadcast transmissions (*revised*).

†Methods of measurements on receivers for frequency modulation broadcast transmissions.

Part 3 Radio frequency measurements on receivers for frequency-modulated sound broadcast emissions

0.5 This standard does not include the methods of tests for safety requirements which are covered by IS : 616-1986* nor with radiation which is covered by IS : 4546-1983†.

0.6 This standard is based on IEC Doc 12A(C.O.) 118 'Draft — Revision of Publications 315-3 Methods of measurement on radio receivers for various classes of emission : Part 3 Radio frequency measurement on receivers for amplitude-modulated sound broadcast emission', issued by the International Electrotechnical Commission (IEC).

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960‡. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard (Part 2) applies to radio receivers for the reception of amplitude-modulated sound broadcast emissions. It deals mainly with measurements using radio-frequency signals applied to the antenna terminals of the receiver, or induced in a magnetic antenna.

1.1.1 This standard shall be read in conjunction with Part 1.

NOTE 1 — Receivers without volume controls or AF power output stages (tuners) are included.

NOTE 2 — Receivers for single-side band and independent side band emissions are not included, nor all the receivers for stereophonic emissions as far as characteristics involving the encoding system are concerned.

2. TERMINOLOGY

2.1 For the purpose of this standard, the terms and definitions given in IS : 12193 (Part 1)§ shall apply.

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*Safety requirements for mains operated electronic and related apparatus for household and similar general use (*second revision*).

†Methods of measurements of radiated and conducted interference from receivers.

‡Rules for rounding off numerical values (*revised*).

§Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements. (*Under preparation*).

SECTION 1 GENERAL

3. CONDITIONS FOR MEASUREMENT

3.1 Standard Measuring Conditions — A receiver is operating under standard measuring conditions when:

a) power supply voltage and frequency are equal to the rated values;

b) standard radio-frequency input signal is applied via the appropriate antenna simulation network to the antenna terminals of the receivers or applied to a standard magnetic field generator to induce the signal into the magnetic antenna of the receiver;

c) audio-frequency output terminals for connection to loudspeakers (if any) are connected to audio-frequency substitute loads, as are any other audio-frequency output terminals, if measurements are to be made at those terminals;

d) receiver is tuned to the applied signal in accordance with **3.2**;

e) volume control (if any) is adjusted so that the output voltage at the main audio-frequency output terminals is 10 dB below the rated distortion-limited output voltage or corresponds to a preferred reference value [*see* **15.1.1** of IS : 12193 (Part 1)*];

f) environmental conditions are within the rated ranges;

g) for stereo receivers, the balance control or its equivalent (if any) is adjusted so that the output voltages of the two channels are equal;

h) tone controls (if any) are adjusted for the flattest possible audio-frequency response (for example, for equal response at 100 Hz, 1 kHz and 10 kHz). This shall be carried out using an AF input signal if AF input terminals are available, otherwise the frequency of 10 kHz given above should be reduced to 2 kHz;

j) automatic frequency control is inoperative, if this can be achieved by means of a user control (*see* Note); and

NOTE — Where a user control for automatic frequency control is provided, measurements shall, in general, be made both with automatic frequency control off (which will allow easy analysis of the results), and with automatic frequency control (on which represents the situation when the receiver is in normal use). The two sets of results shall be clearly identified.

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*Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements. (*Under preparation*).

If the automatic frequency control cannot be made inoperative by means of a user control, it may nevertheless be necessary (or desirable) for the automatic frequency control to be disabled for certain measurements. In this case, the automatic frequency control shall be disabled by temporarily modifying the receiver, the action taken being detained with the results (*see* 3.2).

k) muting control (if any) is in the 'muting off' position.

3.2 Tuning and the Effect of Automatic Frequency Control

3.2.1 *Preferred Tuning Method* — If the manufacturer gives instructions on tuning the receiver, such as the use of a tuning indicator, these instructions shall be followed. In the absence of instructions or of a tuning indicator, the receiver shall be tuned for maximum output voltage at the audio-frequency output terminals under the conditions [with exception of (d)] given in **3.1**, care being taken to avoid overloading the audio-frequency part of the receiver.

3.2.2 *Effect of Automatic Frequency Control* — All tuning operations shall be made with arrangements for automatic frequency control inoperative, if this is possible, except when the performance of the automatic frequency control is being investigated.

When provision is made for the user to render the automatic frequency control inoperative, measurements may be made both with the automatic frequency control in operation and with it disabled. The results shall clearly show whether the automatic frequency control was in operation or not (*see also* Section 6).

3.3 Precautions — Many of the measurements described in this part are likely to be adversely affected by interfering emissions and radio-frequency noise. It is usually essential that a screened room or screened enclosure is available to carry out these measurements. It is also highly desirable to monitor the audio-frequency output signal continuously with a loudspeaker or headphones in order to detect any interference or spurious output signals due to unwanted signals from the test equipment or elsewhere or spurious responses of the receiver.

Measurement accuracy is also affected by inadequate signal-to-noise ratio. When the noise output is independent of the modulation factor (which is not always so), the output with zero modulation shall be checked and if it is larger than —10 dB (unless otherwise stated in this part) with respect to the output with modulation, the result of the measurement shall be rejected and measurement made using an AF band-pass filter to improve the signal-to-noise ratio, sufficiently to restore accuracy.

SECTION 2 SENSITIVITY AND INTERNAL NOISE

4. OUTPUT/INPUT CHARACTERISTICS

4.1 Introduction — Virtually all commercially available receivers for amplitude-modulated sound broadcast emissions use some form of automatic gain control (AGC). To investigate the sensitivity and noise characteristics of such receivers, it is useful to measure and plot curves on the same graph of the AF output with a fixed modulation factor, and the noise output with zero modulation factor as functions of the RF input signal level.

An example of such a graph is given in Fig. 1, which also shows the characteristics whose values may be determined from the curves or the tabulated results of the measurements.

4.2 Methods of Measurement

4.2.1 The receiver is brought under standard measuring conditions (*see* 3.1). An AF voltmeter (preferably a true rms meter), and a noise weighting filter and quasi-peak meter such as distortion and noise level meter are connected across the audio-frequency substitute load at the terminals where AF output measurements are to be made.

NOTE 1 — Wide-band or A-weighted noise measurements may be made in addition, if required [*see* 6 of IS : 12193 (Part 1)*].

NOTE 2 — If ultrasonic components within the band-width of the AF voltmeter are present in the AF output voltage, the voltmeter shall be preceded by a band-limiting filter [*see* 6.1 of IS : 12193 (Part 1)*].

4.2.2 The AF output voltage on the AF voltmeter is noted. The modulation factor is then reduced to zero and the noise output voltage on the noise meter is noted.

4.2.3 The measurements are then repeated for different values of RF input signal level, measurements being made at signal levels low enough to give very low signal-to-noise ratios and high enough (if possible) to explore the overloading of the RF part of the receiver (*see* **21**).

If overloading of the AF part of the receiver occurs at high RF input signal levels, the volume control attenuation is increased by a known amount to eliminate the overloading and measurements are continued. This increased attenuation is taken into account in presenting the results. If no volume control is fitted, the onset of AF overload sets a limit to the

*Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements. (*Under preparation*).

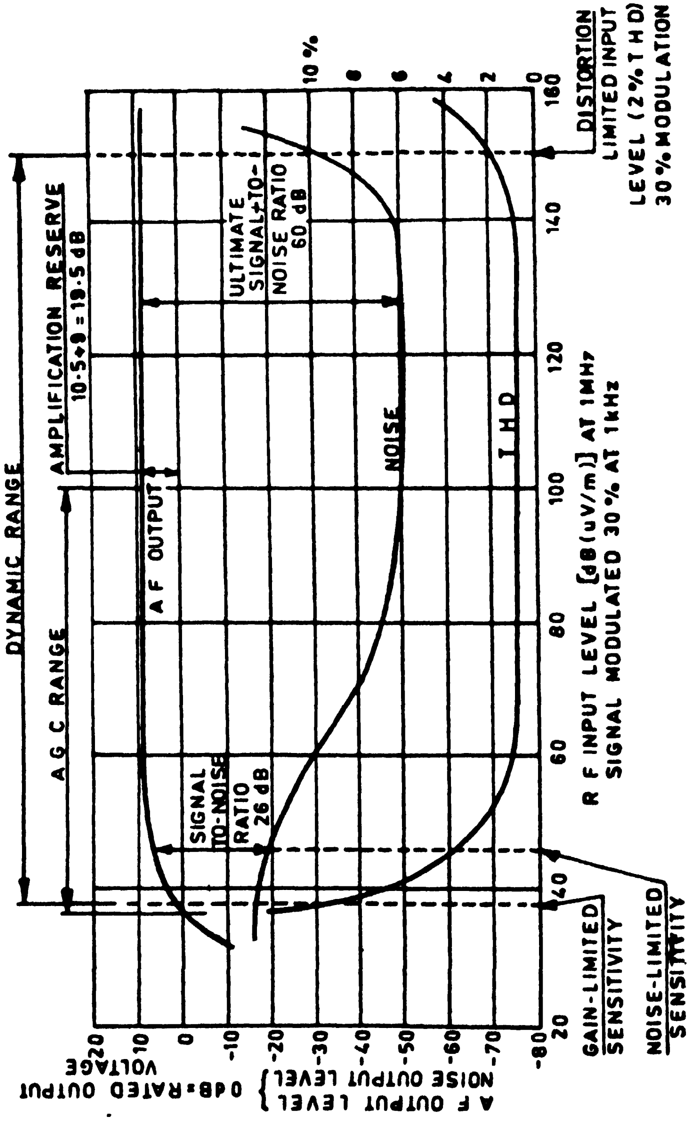


FIG. 1 OUTPUT/INPUT, NOISE OUTPUT/INPUT AND (SELECTIVELY-MEASURED) TOTAL HARMONIC DISTORTION/INPUT CHARACTERISTICS OF AN A. M. BROADCAST RECEIVER

permissible RF input signal level and measurements should be discontinued.

4.2.4 Particularly at high input signal levels, the receiver tuning shall be checked by adjusting the carrier frequency of the signal source before each result is recorded, since the receiver may detune. The extent of any detuning shall be recorded in terms of frequency at each input signal level during this measurement sequence, as the results are of value for the measurement of variation of operating frequency with RF input signal level.

NOTE — A decision whether to record the results of the output/input characteristic measurement with or without retuning is necessary. Unless the tuning variations are large, it is usual to record the result obtained without retuning. If retuning is carried out, this shall be noted with the results.

4.2.5 The results of the measurement of the output/input characteristics and the noise output/input characteristic may be tabulated but are usually presented graphically, with input signal level in dB (mw) [dB (fw)] or dB (μV/m) as abscissa and output or noise output level in dB with respect to a stated reference (usually rated, distortion-limited, output/ voltage). An example is shown in Fig. 1.

4.3 Characteristics Related to the Output/Input and Noise Output/Input Characteristics

4.3.1 *Amplification Reserve* — The amplification reserve is 10·5 dB plus the difference between the AF output level measured with a high level of RF input signal, which shall be 90 dB (fw) or 94 dB (μV/m), unless otherwise stated and the rated (distortion-limited) AF output level, allowance being made for any attenuation introduced by the volume control (if any) to avoid AF overloading. The RF input signal shall be the standard input signal except in respect of level.

NOTE — The factor 10·5 dB is introduced to allow for the modulation factor of the standard input signal being 30 percent. The amplification reserve is thus related to 100 percent modulation.

4.3.2 *Gain-Limited Sensitivity* — The gain-limited sensitivity is the RF input signal level at which the AF output is equal to the rated AF output with any volume controls set at maximum gain.

The RF input signal shall be the standard input signal except in respect of level.

4.3.3 *Noise-Limited Sensitivity* — The noise-limited sensitivity is the RF input signal level required to achieve a specified signal-to-noise ratio, which shall be 26 dB, unless otherwise stated, referred to a signal with 30 percent modulation (36·5 dB referred to 100 percent modulation). The RF input signal shall be the standard input signal except in respect

f level so that the signal level in the signal-to-noise ratio calculation is that produced by 30 percent modulation. The noise output of the receiver shall be measured with the psophometric weighting and quasi-peak meter [*see* **6.2.2** of IS : 12193 (Part 1)*], unless otherwise stated.

4.3.4 *Noise Factor* — The noise factor of a receiver is the ratio of the noise output voltage under specified conditions to the noise output produced by the thermal noise of the resistive part of the source impedance.

Although it is theoretically possible to calculate the latter output, in practice it is easier and more accurate to determine the noise factor directly by using a noise generator whose output level is calibrated directly in terms of noise factor expressed in decibels. To do this, the receiver is brought under the required conditions for measuring noise factor, with the noise generator connected to the antenna terminals through the appropriate antenna substitution network. The output of the noise generator is set to zero and the noise output measured with the wide-band filter and true rms meter. The noise generator output is then increased until the noise output level has risen by 3 dB. The noise factor can then be read from the output indicator of the noise generator.

4.3.5 *Automatic Gain Control* — The performance of the automatic gain control is indicated in detail by the output/input characteristic curve, but for specification purposes a numerical figure-of-merit is useful. The AGC figure-of-merit is the range of RF input signal levels over which the AF output level changes by 10 dB, the RF input signal level corresponding to the upper limit of the range being stated [for example AGC figure-of-merit 65 dB relative to 100 dB (fw)]. This level shall be -20 dB (mw) [100 dB (fw)] or 104 dB (μV/m), unless specified otherwise.

NOTE — Former definitions have specified the upper limit of RF input signal level, giving different values for different types of receiver. Since it is difficult to assign appropriate values for the many different types of receivers, and different classes of performance within each type, it is considered more logical to require the manufacturer to specify this level.

4.3.6 *Dynamic Range (of the RF Input Signal Level)* — The dynamic range of the RF input signal level is the difference in level between the distortion-limited input signal level (*see* **21.1**) and the input signal level required, either to achieve a specified signal-to-noise ratio (which shall be 26 dB, unless otherwise stated) or to achieve rated (distortion-limited) output voltage, whichever (input signal level) is the greater.

*Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements. (*Under preparation*).

4.3.7 *Distortion* — It is often convenient to combine the measurement of the output/input characteristics with measurements of distortion (*see* **21.1** and Fig. 1).

4.3.8 *SINAD* (*Signal-to-Noise and Distortion*) — SINAD measurements treat distortion and noise together as degradations of the output signal [*see* **21.1.1** (b) (4)].

SECTION 3 SELECTIVITY

5. EXPLANATION OF TERMS

5.1 Selectivity — The selectivity of a receiver is a measure of its ability to discriminate between a wanted signal to which the receiver is tuned and unwanted signals entering through the antenna circuit.

Selectivity may be measured in several ways, but only the complex method using simulated interference mentioned below correlates well with the performance of the receiver when in use. Two aspects of receiver performance are included in the concept of selectivity. One is the descrimination against signals whose frequencies are relatively close to that of the wanted signal, and is controlled by the performance of the RF and if tuned circuits or their equivalent, while the other is the discrimination against signals whose frequencies are such that they may produce spurious-responses; for example, the image frequency of a superheat receiver.

5.2 Immunity — The immunity of a receiver is a measure of its rejection of unwanted signals, entering otherwise than through the normal antenna circuit (for example, through the power supply or through an antenna system intended for another frequency range).

5.3 Single-Signal Method — A single-signal method of measurement measures the response of the receiver to an wanted signal in the absence of the wanted signal. The results of such a measurement are meaningful only if the receiver is operating in a linear mode both during the measurement and in the condition to which the measurement results are to be applied.

5.4 Two-Signal Method — A two-signal method of measurement measures the response of the receiver to an unwanted signal in the presence of the wanted signal. The receiver operating mode may be non-linear provided that the results are applied only to conditions where only one strong unwanted signal is present.

A two-signal measurement using sinusoidal modulation of the unwanted signal is fairly simple to perform, but the results do not correlate well with the performance of the receiver when in use.

A two-signal measurement using simulated interference gives results which are a good measure of the true performance of the receiver.

Measurements using three signals are required for some purposes (*see* **10.2**).

5.5 Audio-Frequency Signal-to-Interference Ratio — The audio-frequency (AF) signal-to-interference ratio is the ratio (expressed in dB) between the values of the voltage of the wanted signal and voltage of the interference, measured under specified conditions, at the audio-frequency output of the receiver.

This ratio corresponds closely to the difference in sound pressure level between the wanted programme and the interference.

5.6 Audio-Frequency Protection Ratio — The audio-frequency (AF) protection ratio is the minimum value of the audio-frequency signal-to-interference ratio considered necessary to achieve a subjectively defined reception quality.

This ratio may have different values according to the type of service desired.

5.7 Radio-Frequency Wanted-to-Interfering Signal Ratio — The radio-frequency (RF) wanted-to-interfering signal ratio is the ratio (expressed in dB) between the appropriate values of the radio-frequency voltage or power of the wanted signal and the interfering signal, measured at the input of the receiver under specified conditions.

For example, in the case of amplitude-modulation wanted and interfering transmissions (carrier with double side band) the appropriate values will be the available powers of emfs of the wanted and interfering carriers.

5.8 Radio-Frequency Protection Ratio — The radio-frequency (RF) protection ratio is the value of the radio-frequency wanted-to-interfering signal ratio that enables, under specified conditions, the audio-frequency protection ratio to be obtained at the output of the receiver.

The specified conditions include such diverse parameters as spacing of the wanted and interfering carrier, emission characteristics (type of modulation factor), AF signal characteristics (bandwidth, dynamic compression, etc), receiver input level as well as the receiver characteristics (selectivity and cross-modulation, etc).

5.9 Desensitization (Blocking) — Desensitization (blocking) is an effect, resulting in a given change (generally reduction) in the AF output of a receiver from a wanted modulated radio-frequency input signal of a specified level, caused by an unwanted unmodulated signal on a nearby frequency (*see* **9**). The change in AF output shall be a reduction of 3 dB, unless specified otherwise.

5.10 Cross-Modulation — Cross-modulation is an effect due to non-linearity in a predetector stage or stages, that produces an AF output from a receiver, receiving an unmodulated wanted signal of a specified level, resulting from the modulation of an unwanted signal on a nearby frequency, and is one of the factors affecting adjacent-signal selectivity.

5.11 Intermodulation — Intermodulation is an effect producing an AF output from a receiver, receiving an unmodulated wanted signal of a specified radio-frequency input level, resulting from two simultaneously present unmodulated unwanted signals at specified frequencies (*see* **10**).

5.12 Adjacent- and Alternate-Channel Selectivity — For receivers intended for use with emissions planned with regular channeling, the adjacent-channel selectivity is the selectivity measured by one of the methods given in this part, when the unwanted signal frequency is separated by one channel spacing from the wanted signal frequency. The alternate-channel selectivity is the selectivity measured by one of the methods given in this part, when the unwanted signal frequency is separated by two-channel spacings from the wanted signal frequency.

5.13 Image Rejection Ratio — The image rejection ratio (of a superhet receiver) is the ratio of the radio-frequency input signal level at an image frequency required to produce a specified AF output level from the receiver, to the level of the wanted radio-frequency signal required to produce the same output level.

NOTE 1 — An image frequency is the wanted signal frequency plus or minus twice the value of an intermediate frequency of the receiver, according to whether the frequency-change oscillator is, respectively, higher or lower in frequency than the wanted signal frequency.

If the receiver incorporates more than one frequency changer, there will be more than one image frequency, and for each of these there will be a corresponding image rejection ratio.

NOTE 2 — The automatic frequency control (if any) will not function correctly with an input signal at image frequency.

5.14 Intermediate-Frequency Rejection Ratio — The intermediate-frequency rejection ratio is the ratio of the level of a signal at any intermediate frequency used in the receiver, applied to the radio-frequency input terminals of the receiver which produces a specified AF output level from the receiver, to the level of the wanted radio-frequency signal required to produce the same output level.

5.15 Spurious-Response Rejection Ratio — The spurious-response rejection ratio is the ratio of the radio-frequency input signal level at the interfering frequency, required to produce a specified AF output level from the receiver, to the level of the wanted radio-frequency signal required to produce the same output level.

NOTE — If f_0 is the frequency of the local oscillator, f_1 the intermediate frequency and n an integer, spurious-responses can occur from unwanted signals at the following frequencies:

$f = f_0 + f_1/2$ and $f = nf_0 + f_1$, where n is a positive integer.

5.16 Pass-Band and Bandwidth — The pass-band or X dB bandwidth is the range of input signal frequencies over which the AF output level of the receiver, with an input signal having a specified low modulation frequency and modulation factor exceeds X dB with respect to that at the operating frequency (*see* **3.2**). The bandwidth or pass-band may also be defined for other specified values of response variation. In this part, X is assumed to be equal to 6, unless otherwise specified.

5.17 Attenuation Slope — The attenuation slope is the slope of the graph of AF output level as a function of input signal frequency difference from the operating frequency, with an input signal having a specified low modulation frequency and modulation factor.

6. SINGLE-SIGNAL SELECTIVITY

6.1 Introduction — The single-signal selectivity is the ratio of the RF input signal level at a frequency, whose difference from the operating frequency is specified, required to produce a reference value of audio-frequency output level, to the RF input signal level at the operating frequency required to produce the same output level, the receiver being otherwise under standard measuring conditions.

Unless otherwise specified, the reference output level shall be 10 dB below rated distortion-limited output voltage and the RF input signal level at the operating frequency shall be that of the standard RF input signal.

Supplementary measurements may be made at other stated input signal levels and at other operating frequencies.

6.2 Method of Measurement

a) The receiver is brought under standard measuring conditions;

b) The RF input signal is then detuned by a known amount and its level increased to restore the audio-frequency output level to its value in (a);

c) The RF input signal level and the amount of detuning are noted;

d) The measurement is repeated for other values of detuning; and

e) The measurements may also be repeated with other values of initial RF input signal level or operating frequency.

6.3 Presentation of Results — The results may be tabulated or presented graphically. The values of adjacent and alternate-channel selectivity shall be indicated.

7. TWO-SIGNAL SELECTIVITY USING SINUSOIDAL MODULATION OF THE UNWANTED SIGNAL

7.1 Introduction—The two-signal selectivity using sinusoidal modulation of the unwanted signal is the ratio of the RF input signal level of a modulated signal at a frequency whose difference from the operating frequency is specified, required to produce an audio-frequency output level (unless otherwise stated) 26 dB below that obtained under standard measuring conditions (that is, 36 dB below rated output voltage), in the presence of an unmodulated RF input signal at the operating frequency and standard level.

7.2 Method of Measurement

a) The receiver is brought under standard measuring conditions.

b) The input arrangements are changed to include a suitable combining network and a second signal source whose output is set to zero.

c) The RF input level of the first source is adjusted to allow for the insertion loss of the combining network.

d) Then the modulation is switched off and the second source is tuned to the desired measuring frequency with 30 percent modulation at the standard modulation frequency. The input level of the second source is then adjusted until it produces, when modulated, an AF output level 26 dB below that produced when the wanted signal is modulated, the unwanted signal still being applied but being unmodulated (*see also* 9). The input level of the second source is recorded as the result.

NOTE — This method is specified rather than calling for adjustment of the volume control so that it can apply to equipment without volume controls.

e) The modulations of both sources are then switched off. If the AF output drops by less than 10 dB, the results are being affected by noise or beat-notes and shall be discarded. If a narrow-band filter passing the standard modulation frequency is connected between the AF output terminals and the AF voltmeter, the measurements may be continued but only if noise (rather than a beat-note) affected the wide-band measurement.

f) The measurement is repeated for other frequencies of the second source avoiding frequencies which cause beat-notes.

g) The measurements may be repeated with other specified values of first source level and frequency, and for other specified values of AF output level difference.

7.3 Presentation of Results—The results may be tabulated or presented graphically. The values of adjacent and alternate-channel selectivity shall be indicated.

8. TWO-SIGNAL SELECTIVITY USING SIMULATED INTERFERENCE

8.1 Introduction—This method is essentially a two-signal method which consists in modulating successively, with a given modulation depth, the wanted and the interfering sources a special weighted noise signal, the spectral amplitude distribution of which corresponds to modern dance music programmes.

The inteference effect is measured at the audio-frequency output of the receiver by means of a standardized instrument (*see* **8.2**). The reference value used to define the audio-frequency signal-to-inteference ratio is that which is measured at the audio-frequency output of the receiver with the same instrument, when the wanted signal is modulated with the weighted noise, while the unwanted signal is switched off.

8.2 Output Measurement — For measuring the wanted and interfering signals at the output of the receiver, a special meter is used. This includes a network for weighting the subjective interference effect of different interfering frequencies, in accordance with **6.2.2** of IS : 12193 (Part 1)*.

NOTE — The use of an rms rather than a quasi-peak meter as given in **6** of IS : 12193 (Part 1)* permits more accurate account to be taken of the beat-note predominant with closer frequency spacings and all other effects. This conclusion was drawn from the excellent agreement between the values of radio-frequency protection ratio obtained, either using the objective two-signal method or from subjective listening tests for all values of frequency spacing.

8.3 Noise Signal for Modulating the Signal Generators — The following two conditions are fulfilled by the standard signal simulating modern dance music:

a) Its special constitution corresponds to that of a representative broadcast programme; and

b) Its dynamic range is small so that a sensibly constant reading is obtained on the meter.

The amplitude distortion of modern dance music was taken as a basis, as it is a type of programme with a considerable proportion of high audio-frequencies. However, the dynamic range of this type of

*Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements. (*Under preparation*).

programme is too wide and does not fulfil, therefore, the second condition mentioned in 3.3(b). A signal, which is appropriate for this purpose, is a weighted noise signal, the spectral amplitude distribution of which is fairly close to that of modern dance music (*see* curve *A* of Fig. 2 which is measured using one-third octave filters).

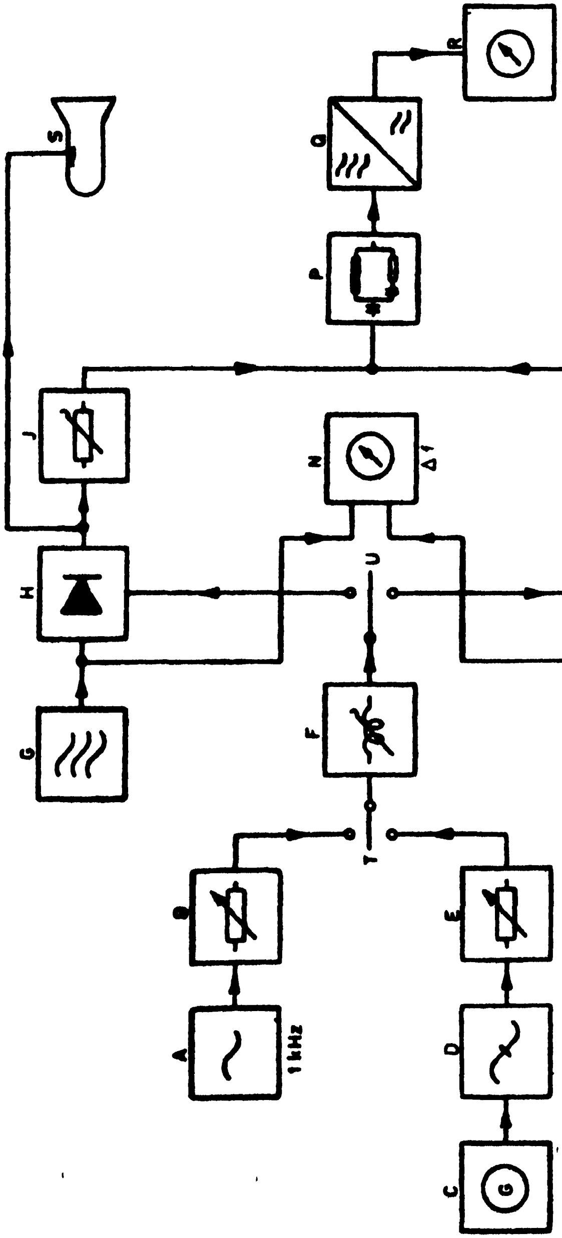
This weighted noise signal may be obtained from a 'white-noise' generator by means of a passive filter circuit as shown in Fig. 2. The frequency-response characteristic of this filter is reproduced as curve *B* of Fig. 2. (It should be noted that the difference between curves *A* and *B* of Fig. 2 is due to the fact that curve *A* is based on measurements with 'one-third octave' filters which pass greater amounts of energy as the bandwidth of the filter increases with frequency.)

The spectrum beyond the required bandwidth of the weighted noise signal shall be restricted by a low-pass filter having a cut-off frequency and a slope such that the bandwidth of the modulating signal is approximately equal to half the standardized bandwidth of emission (*see* Note). The audio-frequency amplitude/frequency characteristic of the modulating stage of the signal generator shall not vary by more than 2 dB up to the cut-off frequency of the low-pass filter.

NOTE — For receivers intended for use with emissions whose channel spacing is *n* kHz, the bandwidth shall be *n*/2 kHz.

8.4 Measuring Arrangements — Figure 3 shows a schematic diagram of the measuring arrangements in which the elements of fundamental importance are drawn in thick outlines. The other elements are measuring and control devices which are required for putting the investigations into practice or for facilitating them.

8.5 Depth of Modulation of the Signal Generators — The depth of modulation of the wanted or interfering signals is determined by the following procedure. The signal generator is first modulated to a depth of 50 percent with a sinusoidal tone at 1 kHz from the generator *A*, adjusted by means of the attenuator *B* and verified by oscilloscope *S* at the radio-frequency outputs of modulators *H* or *L*, and the required audio-frequency voltage is measured at the modulator inputs (switch *U*) by means of the instrument *R*. The amplitude of the noise signal ($C + D$), which is measured with the same measuring instrument *R*, is then adjusted (by means of the attenuator *E*) to be 6 dB lower than the value obtained with the sinusoidal signal: provided that the instrument has a time constant of 200 ms. This corresponds to a depth of modulation of 50 percent measured with a programme meter with quasi-peak indication. Deeper modulation is not appropriate, because on account of its very small dynamic range, the noise would have a more disturbing effect than any real programme.


A
1 kHz
B
C
D
E
F
G
H
J
K
L
M
N
Δf
P
Q
R
S
T
U

A — 1 kHz audio-frequency generator (for calibration of the depth of modulation)

B — calibrated attenuator

C — noise generator

D — noise-shaping filter (*see* Fig. 3)

E — calibrated attenuator

F — low-pass filter

G — signal generator (wanted signal)

H — modulator

J — calibrated attenuator

K — signal generator (interfering signal)

L — modulator

M — calibrated attenuator

N — frequency meter for measuring the frequency difference between signal generators *G* and *K*

P — antenna simulation network (*see* **19** of Part 1)

Q — receiver under test

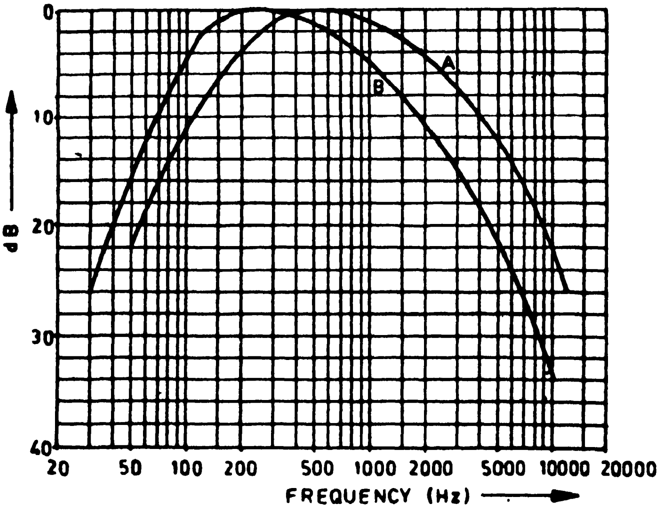
R — rms voltmeter including weighting network (*see* **6** of Part 1)

S — oscilloscope (for monitoring purposes)

T — selector switch for the modulation (1 kHz tone or standardized noise signal)

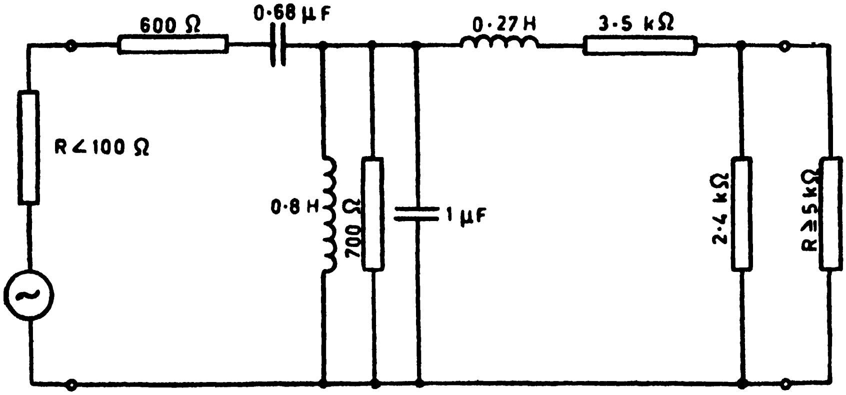
U — change-over switch for the modulation (signal generator *G* or *K*)

FIG. 2 SCHEMATIC OF THE MEASURING ARRANGEMENTS FOR TWO-SIGNAL SELECTIVITY USING SIMULATED INTERFERENCE (*see* 7)



3 (a)

Curve A — Frequency Spectrum of Standardized Noise (Measured with One-Third Octave Filters)



3 (b)

Curve B — Frequency Response Characteristic of Filter Circuit

FIG. 3 FILTER CIRCUIT, WITH FREQUENCY AND SPECTRAL RESPONSES, FOR GENERATING WEIGHTED NOISE SIMULATING INTERFERENCE

8.6 Frequency Separation of the Sources — The unwanted signal frequencies shall be separated from the wanted signal frequency by ± 1, 2, 3, 4, 5, 6, 8, 9 and 10 kHz for co-channel and also at adjacent and alternate channel frequencies.

8.7 Audio-Frequency Signal-to-Interference Ratio — The signal generator (wanted signal) ($G + H + J$) is adjusted to give the standard RF input signal level and modulated with noise according to **8.3** and **8.5.** It produces a signal at the audio-frequency output of the receiver under test Q, which represents, when measured with the instrument R, the AF reference level (0 dB). The noise modulation is then transferred by means of a switch U, from the audio-frequency input of the modulator H of the signal generator (wanted signal) to the audio-frequency input of the modulator of the signal generator (interfering signal), whose carrier frequency is initially set 1 kHz above that of the wanted signal. The modulation of the wanted signal being zero, the radio-frequency level of the interfering signal generator ($K + L + M$) is then adjusted so that the AF output level is less than the reference level by the required audio-frequency signal-to-interference ratio, which shall be 26 dB, unless specified otherwise. The value used shall be stated.

NOTE — There is a relationship between the achievable AF signal-to-interference ratio and the modulating signal bandwidth. Consequently, if a higher value than 26 dB is adopted for the ratio, a reduction in bandwidth may be essential.

8.8 Measurements — The RF output levels of the wanted and unwanted signals are recorded as results, and the measurement repeated with other values of wanted signal level, including low values where the receiver may be operating in a linear mode, and high values where cross-modulation may occur. With low values, the AF output level with both signals unmodulated is also measured, and if this exceeds a level 3 dB below that obtained with the unwanted signal modulated, the result is being affected by receiver noise and shall be discarded.

8.9 Presentation of Results — The results may be presented graphically, with frequency separation as abscissa on a linear scale, unwanted-to-wanted signal level ratio in decibels on a linear scale as ordinate and wanted signal level as parameter. The values of adjacent and alternate-channel selectivity shall be indicated.

8.10 Influence of Non-linear Distortion in the Signal Generators — The non-linear distortion occurring during the modulation process in the signal generator has components which widen the radio-frequency spectrum and this give rise to increased radio-frequency wanted-to-interfering signal ratios in the region of the adjacent channel and the alternate channel (*see* **9**).

The non-linear distortion in the modulators of the signal generators should not, therefore, exceed 2 percent.

8.11 Accuracy — The results obtained with the objective method have been compared with the results of corresponding subjective tests. From these tests, it has been found that objective measurements give a first approximation to those obtained with the subjective method. In cases where the wanted programme is particularly susceptible to interference (for example, speech with long pauses), the difference between the objective measurements and the subjective tests may amount to more than 5 dB.

9. DESENSITIZATION (BLOCKING) (*see* 5)

9.1 Method of Measurement — Blocking may be measured during the measurement of two-signal selectivity by the method given in 7, by noting in Step 4 of the method given in 7.2, the unwanted (unmodulated) input signal level required to reduce the AF output due to the wanted (modulated) signal by 3 dB from the value under standard measuring conditions. It is desirable to extend the measurements to greater values of frequency separation than those required for selectivity measurements.

9.2 Presentation of Results — Blocking may be presented graphically in terms of unwanted input signal level as a function of frequency separation between the wanted and unwanted signals.

10. INTERMODULATION (*see* 5)

10.1 Introduction — Intermodulation is expressed as the radio-frequency input level of two unwanted signals of equal level, which result in an AF output level from the receiver at the standard reference frequency of 26 dB below that which would be obtained if the wanted signal were modulated 30 percent at the standard reference frequency, for a specified radio-frequency input level of this wanted signal, which shall be the standard level, unless otherwise stated.

Intermodulation is caused by the effect of receiver non-linearity on two (or more) applied signals; this gives rise to *distortion components*, which are signals at frequencies $nf_1 \pm mf_2$, where n and m are positive integers and f_1 and f_2 are the input signal frequencies. The sum ($n + m$) is called the *order* of the non-linearity distortion or distortion component.

Receivers may exhibit non-linearity of a high order, resulting in spurious-responses to a very large number of combinations of input signal frequencies. However, for well-designed receivers, consideration of spurious-responses due to selected second and third order distortion components is usually sufficient.

Suitable input signal frequencies, which can give rise to a signal at the operating frequency, an image or intermediated frequency, by the effects described above, are as follows:

a) a sum nearly equal to the intermediate frequency ($f_i \simeq f_1 + f_2$), in which case the unwanted signals shall have frequencies close to, but not equal to, half the value of the intermediate frequency;

b) a difference nearly equal to the intermediate frequency ($f_i \simeq f_1 - f_2$), in which case the unwanted signal having the lower frequency of the two shall have a frequency near to that of the wanted signal, for example, in an adjacent channel;

c) a sum nearly equal to the frequency of the wanted signal ($f_d \simeq f_1 + f_2$), in which case the unwanted signals shall have frequencies close to, but not equal to, half the value of the wanted signal;

d) a difference nearly equal to the frequency of the wanted signal ($f_d \simeq f_1 - f_2$), in which case the unwanted signal having the lower frequency of the two shall have a frequency near to that of the wanted signal, for example, in an adjacent channel;

e) a sum nearly equal to an image frequency ($f_m \simeq f_1 + f_2$), in which case the unwanted signals shall have frequencies close to, but not equal to, half the value of the relevant image frequency; and

f) a difference nearly equal to that between the wanted signal and the nearer unwanted signal ($f_d \simeq 2f_1 - f_2$), in which case the nearer unwanted signal shall have a frequency near to that of the wanted signal, for example, in an adjacent channel.

NOTE — (a) to (e) are due to second order intermodulation, while (f) is due to third order intermodulation.

10.2 Method of Measurement

10.2.1 *Method*

a) The receiver is brought under standard measuring conditions and then the input arrangements are changed to include a combining network for three sources which has adequate [*see* **20** of IS : 12193 (Part 1)*] isolation between sources to prevent intermodulation in the signal sources. The two unwanted signal sources are set to zero output and the level of the wanted signal source adjusted to allow for the insertion-loss of the combining network.

b) Two unwanted unmodulated signals with equal levels, at frequencies f_1 and f_2, are then applied simultaneously with the wanted signal. The frequencies shall be taken from the following list, where (a) to (f) correspond with (a) to (f) in **10.1**.

*Methods of measurement for radio receivers for various classes of emission: Part 1 Generel considerations and methods of measurements. (*Under preparation*).

In all cases, the frequencies shall be chosen in such a way that the receiver audio-frequency output is negligible, if only one unwanted signal is applied and modulated.

With all three signals applied without modulation, the frequency of one of the unwanted signals is adjusted slightly so that the AF output from the receiver is at the standard reference frequency, f_r.

Code	*Basic Equation (Note 1)*	*Spectral Order*	*Difference Frequency (Note 2)*
a)	$f_1 + f_2 = f_1 + 1$ kHz	$f_1 > f_1/2 > f_2$	$f_1 - f_2 = 9$ kHz
b)	$f_1 - f_2 = f_1 + 1$ kHz	$f_1 > f_2$	$\lvert f_2 - f_d \rvert = 9$ kHz
c)	$f_1 + f_2 = f_d + 1$ kHz	$f_1 > f_d/2 > f_2$	$f_1 - f_2 = 9$ kHz
d)	$f_1 - f_2 = f_d + 1$ kHz	$f_1 > f_2$	$\lvert f_2 - f_d \rvert = 9$ kHz
e)	$f_1 + f_2 = f_m + 1$ kHz	$f_1 > f_m/2 > f_2$	$\lvert f_2 - f_m \rvert = 9$ kHz
f)	$2f_1 - f_2 = f_d + 1$ kHz		$\lvert f_1 - f_d \rvert = 9$ kHz

NOTE 1 — If the standard reference frequency (the modulation frequency of the wanted signal) is not 1 kHz, the value used shall be substituted and stated with the results.

NOTE 2 — If the channel spacing of the emissions for which the receiver is designed is not 9 kHz, the appropriate value shall be substituted. This value of frequency difference shall be regarded as a lower limit rather than as a precise value; however, the value can affect the results and shall, therefore, be stated.

c) Then the three signals are applied simultaneously without modulation. The input level of the wanted signal is kept constant, and that of the two unwanted signals (whose levels are kept equal) adjusted, until the AF output level produced is 26 dB below that produced when the wanted signal is modulated 30 percent and one of the unwanted signals is detuned by a few kilohertz so that the amplitude of the beat-note is reduced sufficiently to have no significant effect on the output level measurement (a level 10 dB below that due to the wanted signal is sufficient). The level of the unwanted signals is recorded as the result.

NOTE — This method is specified, rather than calling for adjustment of the volume control so that the method is applicable to equipment without volume controls. The measurements are then repeated for other values of wanted-signal level, and may be repeated at other wanted-signal frequencies.

10.2.2 *Presentation of Results* — The results may be presented as a table or graphically with unwanted-signal level expressed as a function of wanted-signal level.

10.2.3 *Precautions* — Care shall be taken that the results are not affected by intermodulation in the signal generators. This can be checked by inserting a suitable additional attenuator between the combining network and the receiver under test.

If there is no intermodulation between the signal generators, for each additional decibel of attenuation inserted, the level of each of the three signals will have to be increased by 1 dB to get the same result as without the additional attenuator.

If there is intermodulation between the signal generators, and the level of the wanted signal is increased by 1 dB for every decibel inserted in the additional attenuator, the increase in the level of the unwanted signals necessary to restore the audio-frequency output level will be less than 1 dB for each decibel inserted in the additional attenuator. This is due to an increase of the intermodulation between the signal generators.

11. REJECTION OF UNWANTED SIGNALS ENTERING THROUGH THE ANTENNA

11.1 Introduction — In addition to the responses to signals at frequencies near the operating frequency, superheterodyne and similar receivers respond to unwanted signals at the intermediate frequency (or frequencies, in the case of double or multiple superhets), the image frequency (or frequencies) and at harmonics of the signal frequency and other frequencies associated with harmonics of the local-oscillator frequency (or frequencies).

These responses may be measured by single-signal or two-signal methods, and there are important differences both in the conditions of measurement and in the results obtained. It is essential, therefore, to distinguish clearly in the results in which measurement has been made.

The single-signal intermediate-frequency rejection ratio is the ratio in decibels of the input signal level at the intermediate frequency to the input signal level at the operating frequency for equal values of audio-frequency output voltage or power. The input signal level at the tuning frequency shall be the noise-limited sensitivity of the receiver (*see* **4.3.3**) and the audio-frequency output shall be measured selectively if the signal-to-noise ratio is low.

The two-signal intermediate-frequency rejection ratio is the ratio in decibels of the interference signal level at the intermediate frequency, to the RF signal level, at the operating frequency, which fulfils the following conditions:

a) The interference signal frequency and level are such that the unwanted AF signal, due to intermodulation, is at a frequency of

1 kHz and at a level 26 dB below that due to the standard RF input signal; and

b) The wanted signal level is such that the audio-frequency signal-to-noise ratio, in the absence of the unwanted signal, is at least 26 dB.

Unless otherwise stated, the wanted signal level shall be the standard of input signal level.

If the receiver has a balanced input circuit, two values of each of the above characteristics may be measured, one with the intermediate-frequency signal applied in the unbalanced mode, and one with the intermediate-frequency signal applied in the balanced mode. The former is usually more important in practice when the receiver is connected directly to an antenna not shared with another receiver.

The single-signal image rejection ratio is the ratio in decibels of the input signal level at the image frequency to the input signal level at the operating frequency for equal audio-frequency output voltage or power. The input signal level at the operating frequency shall be the noise-limited sensitivity of the receiver (*see* **4.3.3**) and the audio-frequency output shall be measured selectively if the signal-to-noise ratio is low.

The two-signal image rejection ratio is the ratio in decibels of the input signal level at the image frequency to the input signal level at the tuning frequency producing a 26 dB signal-to-interference ratio, that is, for a 1 kHz beat-note output 26 dB below the audio-frequency output due to the signal at the operating frequency.

Spurious-response frequencies are those frequencies (f_s) related to the oscillator frequency f_0 and the intermediate frequency f_i by the following equations:

a) $f_s = f_0 \pm f_i/n$, where n is an integer greater than 1.

Note — The responses for values of n greater than 2 are often but not always insignificant.

b) $f_s \simeq f_0$

Note — This response can only be measured by a two-signal method (*see* **11.3**).

c) $f_s = nf_0 \pm f_i$, where n is zero or an integer greater than 1.

11.2 Single-Signal Method of Measurement

11.2.1 *Method*

a) The method given in **6.2** is followed, except that after completing Step 1, the input signal level is reduced to the noise-limited sensitivity and the AF output level noted;

b) In Step 2, the input signal frequency is set to the appropriate intermediate, image or spurious-response frequency and adjusted slightly for maximum AF output level;

c) The input level is then adjusted to obtain the same AF output level as noted in Step 1 above, and the difference in decibels between this level and the wanted input signal level, is recorded as the result; and

d) The measurement may be repeated with other values of wanted signal level and other operating frequencies.

11.2.2 *Presentation of Results* — The results may be presented as a table or graphically as the difference in decibels between unwanted and wanted signal levels as a function of wanted signal level or frequency, with a clear indication that single-signal measurements were made.

11.3 Two-Signal Method of Measurement

11.3.1 *Method*

a) The method given in **7.2** is followed, except that after completing Step 3, the wanted input signal level is reduced to the noise-limited sensitivity.

b) A band-pass filter (such as a one-third octave filter) passing the standard reference frequency (normally 1 kHz) is connected between the AF substitute load and the output meter, allowance being made for the insertion loss of the filter, if any, and the AF output level is noted.

c) With both signals unmodulated, the frequency of second source is adjusted to the appropriate intermediate, image or spurious-response frequency. Its level is then increased and its frequency varied slightly to obtain maximum AF output level. The second source input level is then adjusted so that the wanted input signal level is recorded as the result.

d) The measurement may be repeated with other values of wanted signal level and other operating frequencies.

11.3.2 *Presentation of Results* — The results may be presented as in **11.2.2**, with a clear indication that two-signal measurements were made.

12. OVERALL AUDIO-FREQUENCY RESPONSE AND ACOUSTIC FREQUENCY CHARACTERISTICS

12.1 Introduction — The overall audio-frequency response is the variation with modulation frequency of the difference in decibels between the AF

output level and that obtained with modulation at the standard reference frequency.

12.2 Method of Measurement

12.2.1 *Method*

a) The receiver is brought under standard measuring conditions and the reference audio-frequency output voltage is noted. The modulation frequency is then varied and the output voltage at each frequency is noted and expressed in decibels relative to the reference voltage. The modulation factor is kept constant at 30 percent unless the receiver is designed to receive emissions having pre-emphasis. In this case, it is preferable to adjust the modulation depth at each frequency in accordance with the pre-emphasis characteristic; to avoid over-modulation at some frequencies, it may be necessary to use a modulation factor of less than 30 percent at other frequencies.

b) If overloading of the AF part of the receiver occurs, either the volume control attenuation shall be increased or the modulation factor reduced, a corresponding factor being applied to the results; and

c) The measurements may be repeated with other values of RF input signal level and frequency.

12.2.2 *Presentation of Results* — The results shall be presented graphically, with modulation frequency plotted logarithmically as abscissa and the output level in decibels as ordinate.

12.3 Acoustic Frequency Characteristics

12.3.1 The acoustic frequency response of a receiver indicates the manner in which the acoustical output of the receiver depends on the modulation frequency.

12.3.2 The method of measurement shall be analogous to that in **12.2.1**, except that the measurement of the electrical output is replaced by measurement of relative sound pressure with respect to standard reference frequency, produced by the loudspeaker under free field conditions. A suitable measuring frequency shall be chosen from those listed in IS : 2264-1963*.

12.3.3 The absolute value of the sound pressure at the reference frequency, produced at a distance of one metre from the reference point,

*Preferred frequencies for acoustical measurements.

measured on the reference axis, expressed in N/m^2 or in dB, referred to the standard reference pressure (20 N/m^2, 0·000 2 $dyne/cm^2$), when the receiver is delivering an output power of 10 dB below the maximum useful output power, shall be stated with the results.

12.3.4 When this measurement is made, the receiver shall be in its normal listening position.

13. PASS-BAND AND ATTENUATION SLOPE (*see* 5.16 and 5.17)

13.1 Introduction — The simplest method of measurement of these characteristics uses an RF input signal modulated with a low-frequency signal at a low modulation factor. Limits are set on the modulation frequency and modulation factor by the necessity of maintaining an adequate signal-to-noise ratio, especially with low RF input signal levels. This is made much easier by the use of an AF band-pass filter at the output.

13.2 Modulation Frequency and Modulation Factor — For small portable receivers with restricted low-frequency (audio) response, a modulation frequency of 125 Hz is usually satisfactory. For higher-quality receivers, increased accuracy and reduced distortion of the modulation due to the effect of the attenuation slope can be achieved by the use of a lower frequency, such as 22·4 Hz, chosen to avoid possible interference from the power supply frequency and its harmonics.

A modulation depth of 10 percent is usually satisfactory, since it further reduces the effect of the attenuation slope in causing distortion of modulation.

13.3 Method of Measurement

13.3.1 *Method*

a) The receiver is brought under standard measuring conditions and then the modulation frequency is changed to the appropriate low frequency (*see* **13.2**) and the modulation factor to 10 percent.

b) An AF band-pass filter (such as one-third octave filter) is introduced between the AF substitute load and the AF voltmeter, allowance being made for the insertion loss (if any) of the filter, and the AF output level noted (*see* Note).

c) The signal carrier frequency is then varied in known steps in each direction from the operating frequency, and the AF output level noted at each step. The difference in dB between this level and that obtained in **13.3.1** (b) is recorded as the result. If possible, the

signal frequencies at which the level difference is 6 dB shall be determined.

d) The measurements may be repeated with other RF input signal levels and frequencies.

NOTE — It is useful to observe the waveform of the modulation, and the effect of noise or possible interference, by means of an oscilloscope connected at the filter input.

13.3.2 *Presentation of Results* — The results may be presented graphically, with level difference in dB expressed as a function of frequency difference, using linear scales. From this graph, the pass-band and attenuation slopes can be determined and tabulated.

14. SELECTIVITY CONTROLS

14.1 The action of selectivity controls may be determined by performing appropriate measurements with the selectivity control in various stated positions. Measurement of the pass-band is usually most appropriate.

15. INPUT BLOCKING AND CROSS-MODULATION

15.1 General — The purpose of this test is to determine whether the selectivity curve is, in fact, achieved when a strong interfering signal is present. Two cases are generally considered, namely:

a) That of an unmodulated signal in the adjacent channel (or channels) from the wanted signal frequency which may overload a stage in the early part of a receiver but which is prevented by the selectivity of the later stages from reaching the detector at an appropriate level. The effect of such overloading is to modify (usually to reduce) the level of the output due to the wanted signal. This effect is known as '*blocking*'.

b) That of an unwanted modulated signal which, due to overloading of a stage in the receiver, will cause the appearance of an interfering signal at the output at the modulation frequency of the unwanted signal. This effect is known as '*cross-modulation*'.

15.1.1 In both the cases mentioned in **15.1**, the measurement is by the two-signal generator method. In both the cases, the protection of the receiver against the unwanted signal is measured by means of the unwanted signal level which produces a specified interference in the presence of a specified desired signal, namely:

a) a reduction of 3 dB in the desired signal at the output in the case of blocking, and

b) appearance of an interference signal in the output level which is 30 dB below the desired signal in case of cross-modulation.

15.2 Methods of Measurement

15.2.1 Two-signal generators shall be connected to the receiver. The desired signal shall be modulated 30 percent at the standard modulation frequency and tuned to a standard frequency; the frequency, at which the measurement is usually made, is 1 kHz; measurements at other frequencies being desirable if the receiver sensitivity varies greatly with frequency. The level is adjusted to a value at which measurements are to be taken. With the unwanted signal maintained at zero, the volume control is adjusted so as to obtain at the output a power at the highest suitable value at which no overloading of any part of the receiver occurs.

15.2.2 The unwanted signal is then applied without modulation and its level is adjusted so as to produce a decrease of 3 dB in the output signal. The level thus obtained is a measure of the protection of the receiver against blocking for the signal specified.

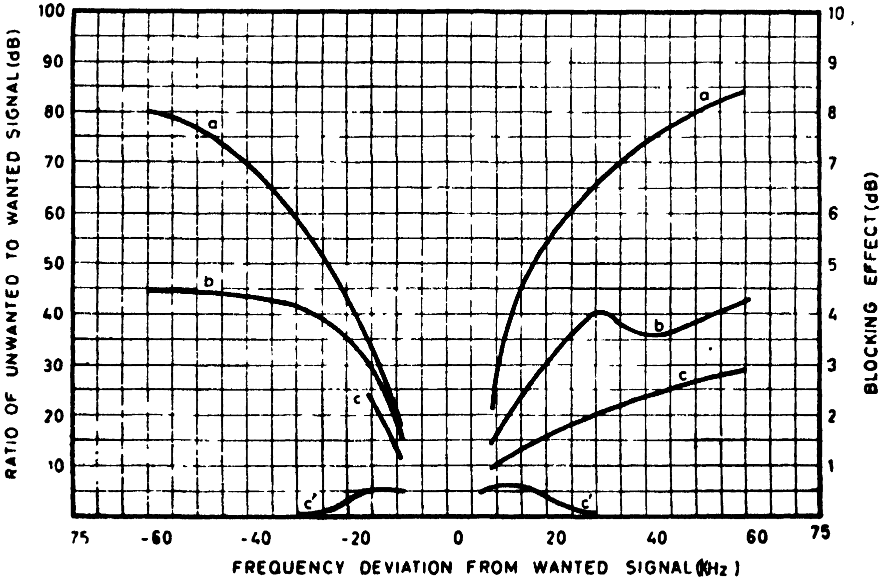
15.2.3 The modulation of the desired signal is then removed. The unwanted signal is modulated 30 percent at the standard modulation frequency and its level adjusted so as to obtain an output signal 30 dB below the reference power. When this is being done, the modulation of the unwanted signal is removed, and that of the desired signal reapplies; if the decrease in output due to blocking is appreciable, the volume control of the receiver is again adjusted so as to restore the output power to the reference level. The modulation of the desired signal is then removed and that of the unwanted signal reapplied, and the measurement repeated by means of successive approximations until there occurs simultaneously a signal equal to the reference power and an interfering signal 30 dB lower. The level of this unwanted signal is a measure of the protection of the receiver against cross-modulation for the desired signal specified.

15.2.4 The entire measurement of blocking and cross-modulation is repeated for different frequencies of the unwanted signal differing in frequency from the wanted signal by $\pm$ 10, $\pm$20, ..., $\pm$100 kHz, depending upon the degree of protection achievable.

15.2.5 If the receiver is provided with manual or variable selectivity control, measurements shall be conducted both at the maximum and minimum positions and also at the minimum value suitable for reception of broadcast signals.

15.3 Graphical Representation — Taking the level of the desired signal as a parameter, the results of the measurements of blocking and cross-modulation are plotted as two curves, which can be drawn on the same graph by plotting the frequency differences expressed in kHz as abscissa

on a linear scale marked with positive and negative signs and the ratio of the levels of unwanted signal and the wanted signal respectively, expressed in dB, as ordinate on a linear scale. An example is shown in Fig. 4.



Two-signal selectivity curve and blocking curve (c')

Input Level for a 86 dB (V)
Input Level for b 46 dB (V)
Input Level for c and c' 26 dB (V) at an operating frequency of 1 MHz

FIG. 4 TWO-SIGNAL SELECTIVITY CURVE AND BLOCKING CURVE AT AN OPERATING FREQUENCY OF 1 MHz

SECTION 4 INTERFERENCE DUE TO INTERNAL SOURCES

16. SINGLE-SIGNAL BEAT-NOTES

16.1 Introduction — Unwanted signals may be generated by several processes in the receiver. Such signals include harmonics of the intermediate frequency or of any internal oscillators, together with frequencies generated by the action of non-linearities in the receiver on these frequencies and wanted and unwanted signals. Receivers using digital techniques may generate a clock frequency f_0 and or sub-multiples of f_0 and of oscillator frequency.

The relative importance of these unwanted signals depends on the design and application of the receiver, including the particular frequencies of the emissions receivable at the actual location of the receiver when in use. However, some of these unwanted signals are of general importance as follows:

a) Harmonics of the intermediate frequency : nf_i where n is a positive integer and f_i is the intermediate frequency. These give rise to AF beat-notes (whistles) when $f_d = nf_i$, where f_d is the operating frequency.

b) Intermodulation products of harmonics of the wanted signal and oscillator frequencies: $mf_0 - nf_d$, where m and n are positive integers and f_0 is the oscillator frequency. These give rise to AF beat-notes (whistles) when

$$f_d = f_i (m + 1) / (n - m)$$

As a consequence of both of these processes, beat-notes may occur at operating frequencies $f_d = p.f_i$, where. for values of m and n up to 8, p may have the following values:

1/6, 1/5, 1/4, 2/7, 1/3. 2/5. 1/2, 3/5, 2/3, 3/4.

4/5, 5/4. 4/3, 3/2, 5/3, 2, 5/2, 3, 7/2, 4, 5, 6, 7 and 8.

Of these, $p = 2$ and $p = 3$ are the most important for MF band receivers of conventional design.

c) Signals related in frequency to local clock or oscillator frequencies: mf_c/n, where m and n are positive integers and f_c is a clock frequency. These give rise to AF beat-notes when $f_d = f_i\,m/n - mf_0/n$, where f_0 is a local note when $f_d = f_i\,m/(n - m)$.

All pairs of m and n which can give beat-notes, in any frequency band for which the receiver is designed, should be checked.

The strength of a beat-note, for a specified RF input signal level, may be expressed as the difference in AF output level due to the beat-note caused by an unmodulated signal (the input signal frequency being adjusted so that the beat-note frequency is equal to the standard reference frequency); to be level which would be produced by a signal at the same frequency modulated 100 percent at the standard reference frequency (that is, + 10·5 dB relative to that produced by a 30 percent modulated signal). Alternatively, the strength may be expressed as the percentage modulation factor producing the same output level as the beat-note.

NOTE — By relating the strength of the beat-note to the output produced by a 100 percent modulated signal, the value expressed as a level difference is directly related to that expressed as percentage modulation factor.

16.2 Method of Measurement

16.2.1 *Method*

a) The receiver is brought under standard measuring conditions and the input signal frequency changed to that at which a beat-note may occur.

b) The input signal frequency is adjusted to produce maximum AF output level (if any, beat-note is present).

c) The receiver tuning is adjusted to reduce the beat-note frequency to zero and the input signal frequency temporarily readjusted to determine the operating frequency which is recorded.

NOTE — A second signal source may be used for this purpose. It is helpful to listen to the output when setting the beat-note frequency to zero.

d) The input signal frequency is returned to its previous value, 30 percent modulation is applied at the standard reference frequency and the AF output level noted. It may be desirable to adjust the volume control (if any) if the AF output level is low. An AF band-pass filter may also be included, if required.

e) The modulation is then reduced to zero and the signal frequency adjusted slightly so that the beat-note frequency is equal to the standard reference frequency, choosing the stronger response, if there are more than one. The AF output level is then recorded.

f) The difference between this level and that obtained in (d) is recorded as the result. Alternatively, the result may be expressed as percentage modulation factor:

$$m = \text{antilog} \left[\left(L_5 - L_4 - 10{\cdot}5 \right)/20 \right] \times 100 \text{ percent}$$

where

L_4 = AF output level obtained in (d), and

L_5 = AF output level obtained in (e).

g) The measurements are repeated at other appropriate signal frequencies.

16.2.2 ***Presentation of Results*** — The results may be presented as a table or a spectrum diagram, with level difference or modulation factor as ordinate and frequency as abscissa.

The measurements may be repeated with other values of input signal level at a given frequency, and the results presented graphically with level difference or modulation factor as ordinate and input signal level as abscissa.

17. ACOUSTIC EFFECTS

17.1 Acoustic feedback may occur between the loudspeaker and components in the RF part of the receiver. For the measurement of these effects, the method given in **16** of IS : 12193 (Part 1)* shall be employed, except that an unmodulated RF input signal at the operating frequency is applied in addition, and measurements are repeated for appropriate values of the level and frequency of this signal, especially high values, which are likely to produce greater effects.

The conditions under which each result was obtained shall be stated with the results.

NOTE — Care is necessary to avoid acoustic feedback to the RF signal source.

18. UNWANTED OSCILLATIONS

18.1 The receiver shall be operated under various stated conditions chosen as likely to produce unwanted self-oscillation, such as extreme settings of the tuning, volume and tone controls, with and without a signal, with and without an antenna (unless the antenna is an integral part of the receiver or not intended to be detached by the user), with and without a signal earth connection (if provided), (safety earth connection shall not be removed), and with and without connections to external equipment. Any anomalous output, such as whistles, noise or distortion may indicate oscillation, which should be further investigated.

19. INTERFERENCE AT THE POWER SUPPLY FREQUENCY AND ITS HARMONICS (HUM)

19.1 Introduction — The radio-frequency stages, particularly mixer stages, of a receiver may give rise to hum due to amplitude or frequency modulation of the signal by low (audio) frequency voltages from the supply mains or elsewhere, or electric or magnetic fields. Automatic frequency control circuits, in particular, can cause hum due to frequency-modulation of the local oscillator.

Measurements shall be made at rated supply voltage and at the appropriate over- and under-voltages [*see* **13.4** and Table 2 of IS : 12193 (Part 1)*].

19.2 Method of Measurement

19.2.1 *Method*

a) The receiver is brought under standard conditions and then the modulation frequency is changed to 80 Hz so that comparison of

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*Methods of measurement for radio receivers for various classes of emission: Part 1 General considerations and methods of measurements (*Under preparation*).

the signal and hum is less influenced by the frequency response of the audio-frequency stages.

b) The modulation is then removed and the hum output is measured as separate spectral components with a wave analyzer or as total hum output with a true rms meter.

c) The measurements shall be repeated at the appropriate over- and under-voltages.

d) The measurements may be repeated at other input signal levels and with automatic frequency control in operation.

NOTE — Care shall be taken that the input signal is sufficiently free from hum modulation. For example, a check may be made with either the signal source, the receiver or both supplied from batteries.

19.2.2 *Presentation of Results* — The results may be tabulated or presented as a spectrum diagram.

SECTION 5 DISTORTION

20. INTRODUCTION

20.1 Distortion present in the AF output of a receiver may be expressed in several ways. It is usually sufficient to determine in detail the distortion characteristics of the AF part of the receiver with an AF input signal, and to confine overall measurements to those of harmonic distortion. A valid investigation of demodulator distortion (which may be higher than that of the AF part of the receiver) requires the use of high modulation frequencies and modulation factors, but the maximum modulation frequency of the emissions for which the receiver is designed shall not be exceeded. Measurements at low modulation frequencies are also of importance, since distortion may arise through AGC action. Care is required that distortion in the modulator of the signal source is low enough not to affect the results. A level difference of 10 dB between each modulator distortion component and that due to the receiver is sufficient.

21. OVERALL HARMONIC DISTORTION, DISTORTION-LIMITED AF OUTPUT AND DISTORTION-LIMITED INPUT LEVEL

21.1 Method of Measurement

21.1.1 *Method*

a) The receiver is brought under standard measuring conditions and the harmonic content of the AF output measured.

b) The measurement may be repeated under the following conditions:

1) with the volume control (if any) adjusted so that rated total harmonic distortion is produced, the distortion-limited AF output level, voltage and/or power are noted. If there is no volume control, the modulation depth is increased until rated total harmonic distortion is produced;

2) with the volume control (if any) in the position for standard measuring conditions, and with an input signal modulation factor of 80 percent, the overall harmonic distortion with 80 percent modulation may be measured;

3) with the volume-control (if any) in the position for standard measuring conditions, and with the input signal modulated 30 percent, the input signal level is increased until rated total harmonic distortion is produced. This input signal level is the distortion-limited input level for a specified value of modulation factor and at rated total harmonic distortion; and

4) with other specified values of modulation factor and frequency, and/or RF input signal level.

NOTE — Harmonic distortion measurements are valid only for modulation frequencies for which the significant harmonics lie within the pass-band of the AF part of the receiver, including the demodulator. The highest frequency, for which this is true, may be deduced approximately for the overall AF response measured with a high level of RF input signal, and the order of the highest significant harmonic measured at lower modulation frequencies.

With low values of RF input signal level, the noise output of the receiver will be comparable with or greater than that due to the harmonics of the modulation frequency. If the distortion is measured with a distortion factor meter, the results include the effect of noise, and are termed SINAD (signal-to-noise and distortion) measurements and may be specified instead of signal-to-noise ratios. For the measurement of distortion alone, selective methods using a wave-analyzer or spectrum analyzer may be employed, the rms sum of the amplitudes of the individual harmonics giving the total harmonic content of the AF output signal.

21.1.2 *Presentation of Results* — The results may be tabulated or, in the case of **21.1.1**(b)(4), presented graphically (*see* Fig. 1).

22. DISTORTION DUE TO INACCURACY OF TUNING

22.1 Method of Measurement

a) The method described in **21.1** is employed, measurements being made at several input signal frequencies close to the operating

frequency of the receiver, within the limits of the pass-band (*see* **5.16**).

b) The results may be presented graphically, with distortion expressed as a function of the difference between the input signal frequency and the operating frequency.

SECTION 6 MISCELLANEOUS

23. TUNING AND AUTOMATIC FREQUENCY-CONTROL CHARACTERISTICS

23.1 Introduction — The tuning characteristic of a receiver shows the relation between the audio-frequency output voltage and the signal frequency when the signal frequency is varied each side of the operating frequency.

The tuning characteristic is modified by the action of automatic frequency control. The characteristic measured with automatic frequency control in operation shows the pull-in and hold-in ranges.

23.2 Method of Measurement

23.2.1 *Method*

a) The receiver is brought under standard measuring conditions.

b) The input signal frequency is varied in steps either side of the original frequency and the AF output level is measured at each step and recorded as the result.

c) The measurement may be repeated at other input signal levels.

d) If automatic frequency control is fitted, the measurements shall be repeated with it in operation. The input signal frequency is first varied stepwise away from the original frequency until a sudden drop in audio frequency output occurs, and then varied stepwise towards and beyond the original frequency until the output suddenly drops again. The input signal is then varied back towards the original frequency again. From these measurements, the hold-in and pull-in ranges of the automatic frequency control may be determined.

e) Alternatively, instead of monitoring the audio output level, the local oscillator frequency may be measured with a frequency counter at each input signal frequency.

NOTE — Some types of automatic frequency control do not function satisfactorily if the pull-in range is wide, because the receiver is detuned from a weak

signal in the presence of a strong signal on a nearby frequency. Other types of automatic frequency control can have a very wide hold-in range associated with a narrow pull-in range and these are affected less by strong signals. Due to the wide variety of effects that may occur, it is difficult to standardize a method of measurement; a method as given in **9** is suitable. The change of audio-frequency output when the unwanted carrier is applied is compared with that occurring, due to blocking, with the AFC inoperative, and any greater change with AFC operative is a measure of the interference of the unwanted carrier with the AFC action.

23.2.2 *Presentation of Results* — The results may be presented graphically with the AF output level plotted in decibels on a linear scale, and the difference between the input signal frequency and the operating frequency (the detuning) plotted linearly as abscissa, or as local oscillator frequency plotted linearly as ordinate and the difference in frequency plotted linearly as abscissa.

24. MAXIMUM OUTPUT POWER

24.1 The maximum output power is the total electrical output power a receiver is capable of delivering under certain conditions, irrespective of the distortion present.

24.2 For this measurement, the receiver shall be tuned to a signal of 5 mV or -46 dB (V) at 1 000 kHz, modulated 30 percent with standard modulation frequency, the signal being applied as specified. The output of the receiver shall be measured across the load with the volume control adjusted to obtain maximum output power.

25. MAXIMUM USEFUL OUTPUT POWER

25.1 The maximum useful output power of a receiver is the lowest value of output power at which the overall harmonic distortion amounts to 10 percent.

25.2 The method of measurement shall be the same as under **21.1** and shall be repeated for that position of the volume control which gives an overall harmonic distortion of 10 percent. The corresponding output power shall be measured and noted as the maximum useful output power.

25.3 The measurement shall be repeated at the over-voltages and under-voltages specified.

(*Continued from page* 2)

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